IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Shilin Chen
Serial No.:	To be Assigned
Filing Date:	January 27, 2004
Group Art Unit:	To be Assigned
Examiner:	To be Assigned
Title:	**FORCE-BALANCED ROLLER-CONE BITS, SYSTEMS, DRILLING METHODS, AND DESIGN METHODS**

Commissioner of Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

REQUEST FOR INTERFERENCE
WITH PATENT PURSUANT TO 37 C.F.R. 1.607

The present Application includes Claims 1-18 copied from U.S. Patent No. 6,612,384 (the "'384 Patent"). Accordingly, Applicant respectfully requests that the Examiner declare an Interference between the present Application and the '384 Patent in view of the following comments.

CLAIMS

For the convenience of the Examiner, all pending claims of the present Application are shown below in numerical order.

1. A roller cone drill bit, comprising:

a bit body;

three roller cones attached to said bit body and able to rotate with respect to said bit body;

a plurality of cutting elements arranged on each of the cones so that cutting elements on adjacent cones intermesh between the adjacent cones, the cutting elements being arranged such that a projected area of said cutting elements in contact with a formation during drilling is substantially the same for each of the cones.

2. The drill bit according to Claim 1, wherein axial force exerted on the bit during drilling is substantially balanced between the cones.

3. The drill bit according to Claim 1, wherein said cutting elements are disposed on each cone, such that work performed by each cone during drilling is substantially the same as the work performed each of the other cones.

4. The drill bit according to Claim 1, wherein a depth of penetration for each cutting element into a formation during drilling is substantially the same for each of the cones.

5. The drill bit according to Claim 1, wherein a distribution of axial force on the bit is optimized.

6. The drill bit according to Claim 1, wherein said cutting elements comprise superhard inserts.

7. The drill bit according to Claim 1, wherein said cutting elements comprise tungsten carbide inserts.

8. The drill bit according to Claim 1, wherein said cutting elements comprise milled steel teeth.

9. The drill bit according to Claim 8, wherein said cutting elements further comprise hardface coating.

10. A roller cone drill bit, comprising:

a bit body;

three roller cones attached to said bit body and able to rotate with respect to said bit body;

a plurality of cutting elements arranged on each of the cones so that cutting elements on adjacent cones intermesh between the adjacent cones, the cutting elements being arranged such that a depth of penetration for the cutting elements into a formation during drilling is substantially the same for each of the cones.

11. The drill bit according to Claim 10, wherein axial force exerted on the bit during drilling is substantially balanced between the cones.

12. The drill bit according to Claim 10, wherein said cutting elements are disposed on each cone, such that work performed by each cone during drilling is substantially the same as the work performed by each of the other cones.

13. The drill bit according to Claim 10, wherein a projected area of said cutting elements in contact with a formation during drilling is substantially the same for each of the cones.

14. The drill bit according to Claim 10, wherein a distribution of axial force on the bit is optimized.

15. The drill bit according to Claim 10, wherein said cutting elements comprise superhard inserts.

16. The drill bit according to Claim 10, wherein said cutting elements comprise tungsten carbide inserts.

17. The drill bit according to Claim 10, wherein said cutting elements comprise milled steel teeth.

18. The drill bit according to Claim 17, wherein said cutting elements further comprise hardface coating.

REMARKS

Claims 1-18 are copied from the '384 Patent and correspond to Claims 29-30, 34, 41-42, 50, 53, 55-58, 62, 72-73, 78, 81 and 83-84, respectively, of the '384 Patent. Applicant notes that Claims 1-18 also correspond exactly to Claims 85-86, 90, 97-98, 106, 109, 111-14, 118, 125-26, 134, 137 and 139-40, respectively, of U.S. Patent Application No. 10/410,470, published on October 16, 2003 (Publication No. U.S. 2003/0192721 A1). Applicant respectfully submits that an interference should be declared because, as shown in the table below, the present Application and the '384 Patent claim the same invention.

The Present Application	**The '384 Patent**
1. A roller cone drill bit, comprising: a bit body; three roller cones attached to said bit body and able to rotate with respect to said bit body; a plurality of cutting elements arranged on each of the cones so that cutting elements on adjacent cones intermesh between the adjacent cones, the cutting elements being arranged such that a projected area of said cutting elements in contact with a formation during drilling is substantially the same for each of the cones.	29. A roller cone drill bit, comprising: a bit body; three roller cones attached to said bit body and able to rotate with respect to said bit body; a plurality of cutting elements arranged on each of the cones so that cutting elements on adjacent cones intermesh between the adjacent cones, the cutting elements being arranged such that a projected area of said cutting elements in contact with a formation during drilling is substantially the same for each of the cones.
2. The drill bit according to Claim 1, wherein axial force exerted on the bit during drilling is substantially balanced between the cones.	30. The drill bit according to claim 29, wherein axial force exerted on the bit during drilling is substantially balanced between the cones.
3. The drill bit according to Claim 1, wherein said cutting elements are disposed on each cone, such that work performed by each cone during drilling is substantially the same as the work performed each of the other cones.	34. The drill bit according to claim 29, wherein said cutting elements are disposed on each cone, such that work performed by each cone during drilling is substantially the same as the work performed each of the other cones.
4. The drill bit according to Claim 1, wherein a depth of penetration for each cutting element into a formation during drilling is substantially the same for each of the cones.	41. The drill bit according to claim 29, wherein a depth of penetration for each cutting element into a formation during drilling is substantially the same for each of the cones.

The Present Application	The '384 Patent
5. The drill bit according to Claim 1, wherein a distribution of axial force on the bit is optimized.	42. The drill bit according to claim 29, wherein a distribution of axial force on the bit is optimized.
6. The drill bit according to Claim 1, wherein said cutting elements comprise superhard inserts.	50. The drill bit according to claim 29, wherein said cutting elements comprise superhard inserts.
7. The drill bit according to Claim 1, wherein said cutting elements comprise tungsten carbide inserts.	53. The drill bit according to claim 29, wherein said cutting elements comprise tungsten carbide inserts.
8. The drill bit according to Claim 1, wherein said cutting elements comprise milled steel teeth.	55. The drill bit according to claim 29, wherein said cutting elements comprise milled steel teeth.
9. The drill bit according to Claim 8, wherein said cutting elements further comprise hardface coating.	56. The drill bit according to claim 55, wherein said cutting elements further comprise hardface coating.
10. A roller cone drill bit, comprising: a bit body; three roller cones attached to said bit body and able to rotate with respect to said bit body; a plurality of cutting elements arranged on each of the cones so that cutting elements on adjacent cones intermesh between the adjacent cones, the cutting elements being arranged such that a depth of penetration for the cutting elements into a formation during drilling is substantially the same for each of the cones.	57. A roller cone drill bit, comprising: a bit body; three roller cones attached to said bit body and able to rotate with respect to said bit body; a plurality of cutting elements arranged on each of the cones so that cutting elements on adjacent cones intermesh between the adjacent cones, the cutting elements being arranged such that a depth of penetration for the cutting elements into a formation during drilling is substantially the same for each of the cones.
11. The drill bit according to Claim 10, wherein axial force exerted on the bit during drilling is substantially balanced between the cones.	58. The drill bit according to claim 57, wherein axial force exerted on the bit during drilling is substantially balanced between the cones.

The Present Application	The '384 Patent
12. The drill bit according to Claim 10, wherein said cutting elements are disposed on each cone, such that work performed by each cone during drilling is substantially the same as the work performed by each of the other cones.	62. The drill bit according to claim 57, wherein said cutting elements are disposed on each cone, such that work performed by each cone during drilling is substantially the same as the work performed by each of the other cones.
13. The drill bit according to Claim 10, wherein a projected area of said cutting elements in contact with a formation during drilling is substantially the same for each of the cones.	72. The drill bit according to claim 57, wherein a projected area of said cutting elements in contact with a formation during drilling is substantially the same for each of the cones.
14. The drill bit according to Claim 10, wherein a distribution of axial force on the bit is optimized.	73. The drill bit according to claim 57, wherein a distribution of axial force on the bit is optimized.
15. The drill bit according to Claim 10, wherein said cutting elements comprise superhard inserts.	78. The drill bit according to claim 57, wherein said cutting elements comprise superhard inserts.
16. The drill bit according to Claim 10, wherein said cutting elements comprise tungsten carbide inserts.	81. The drill bit according to claim 57, wherein said cutting elements comprise tungsten carbide inserts.
17. The drill bit according to Claim 10, wherein said cutting elements comprise milled steel teeth.	83. The drill bit according to claim 57, wherein said cutting elements comprise milled steel teeth.
18. The drill bit according to Claim 17, wherein said cutting elements further comprise hardface coating.	84. The drill bit according to claim 83, wherein said cutting elements further comprise hardface coating.

Applicant's compliance with 37 C.F.R. §1.607 is indicated below.

I. 37 C.F.R. §1.607(a)(1)

Applicant respectfully requests that the Examiner declare an interference between the present Application and U.S. Patent No. 6,612,384.

II. 37 C.F.R. §1.607(a)(2)

Applicant proposes the following count:

A roller cone drill bit, comprising:

a bit body;

three roller cones attached to said bit body and able to rotate with respect to said bit body;

a plurality of cutting elements arranged on each of the cones so that cutting elements on adjacent cones intermesh between the adjacent cones, the cutting elements being arranged such that a projected area of said cutting elements in contact with a formation during drilling is substantially the same for each of the cones.

III. 37 C.F.R. §1.607(a)(3)

Claim 29 of U.S. Patent No. 6,612,384 corresponds exactly to the proposed count.

IV. 37 C.F.R. §1.607(a)(4)

Claim 1 of the present Application corresponds exactly to the proposed count.

V. 37 C.F.R. §1.607(a)(5) SUPPORT FOR COPIED CLAIMS

Applicant respectfully contends that Claims 1-18 of the present Application are fully supported by the specification of the present Application as originally filed. Applicant provides below, examples of specific portions of the specification that support specific claim limitations of Claims 1-18. Applicant does not intend this list to be exhaustive of all support for Claims 1-18 that is present in the specification of the present Application.

For the convenience of the Examiner, Applicant has reproduced specific portions of the specification of the present Application in the attached Exhibit A. Such portions were reproduced from the cited "Support in the Specification" section below and are applied to their respective claim limitations in Exhibit A.

Claims	**Support in the Specification**
1. A roller cone drill bit, comprising:	Figure 11.
a bit body;	Figure 11.
three roller cones attached to said bit body and able to rotate with respect to said bit body;	Figure 11. Page 12, lines 3-9.
a plurality of cutting elements arranged on each of the cones so that cutting elements on adjacent cones intermesh between the adjacent cones, the cutting elements being arranged such that a projected area of said cutting elements in contact with a formation during drilling is substantially the same for each of the cones.	Page 8, lines 20-21. Page 16, lines 14-18. Page 17, lines 5-8. Page 17, lines 23-24. *See* U.S. Provisional Application 60/098,466 ("'466 Provisional")[1], Pages 5 and 7.
2. The drill bit according to Claim 1, wherein axial force exerted on the bit during drilling is substantially balanced between the cones.	Page 7, lines 7-9. Page 24, lines 2-4.
3. The drill bit according to Claim 1, wherein said cutting elements are disposed on each cone, such that work performed by each cone during drilling is substantially the same as the work performed each of the other cones.	Page 12, line 27 – Page 13, line 13. Page 15, line 28 – Page 16, line 4. Page 16, lines 9-18.

[1] The '466 Provisional is incorporated by reference into the present Application. *See* Present Application, Page 1, lines 7-8.

Claims	Support in the Specification
4. The drill bit according to Claim 1, wherein a depth of penetration for each cutting element into a formation during drilling is substantially the same for each of the cones.	Page 11, line 12 – Page 12, line 21.
5. The drill bit according to Claim 1, wherein a distribution of axial force on the bit is optimized.	Page 1, lines 11-12. Page 7, line 32 – Page 8, line 2. Page 24, lines 2-4.
6. The drill bit according to Claim 1, wherein said cutting elements comprise superhard inserts.	Page 4, lines 9-10.
7. The drill bit according to Claim 1, wherein said cutting elements comprise tungsten carbide inserts.	Page 4, lines 9-10.
8. The drill bit according to Claim 1, wherein said cutting elements comprise milled steel teeth.	Page 4, line 7.
9. The drill bit according to Claim 8, wherein said cutting elements further comprise hardface coating.	Page 4, lines 7-9.
10. A roller cone drill bit, comprising:	Figure 11.
a bit body;	Figure 11.
three roller cones attached to said bit body and able to rotate with respect to said bit body;	Figure 11. Page 12, lines 3-9.
a plurality of cutting elements arranged on each of the cones so that cutting elements on adjacent cones intermesh between the adjacent cones, the cutting elements being arranged such that a depth of penetration for the cutting elements into a formation during drilling is substantially the same for each of the cones.	Page 11, line 12 – Page 12, line 21

Claims	Support in the Specification
11. The drill bit according to Claim 10, wherein axial force exerted on the bit during drilling is substantially balanced between the cones.	Page 7, lines 7-9. Page 24, lines 2-4.
12. The drill bit according to Claim 10, wherein said cutting elements are disposed on each cone, such that work performed by each cone during drilling is substantially the same as the work performed by each of the other cones.	Page 12, line 27 – Page 13, line 13. Page 15, line 28 – Page 16, line 4. Page 16, lines 9-18.
13. The drill bit according to Claim 10, wherein a projected area of said cutting elements in contact with a formation during drilling is substantially the same for each of the cones.	Page 8, lines 20-21. Page 16, lines 14-18. Page 17, lines 5-8. Page 17, lines 23-24. *See* '466 Provisional, Pages 5 and 7.
14. The drill bit according to Claim 10, wherein a distribution of axial force on the bit is optimized.	Page 1, lines 11-12. Page 7, line 32 - Page 8, line 2. Page 24, lines 2-4.
15. The drill bit according to Claim 10, wherein said cutting elements comprise superhard inserts.	Page 4, lines 9-10.
16. The drill bit according to Claim 10, wherein said cutting elements comprise tungsten carbide inserts.	Page 4, lines 9-10.
17. The drill bit according to Claim 10, wherein said cutting elements comprise milled steel teeth.	Page 4, line 7.
18. The drill bit according to Claim 17, wherein said cutting elements further comprise hardface coating.	Page 4, lines 7-9.

VI. REQUEST FOR THE BENEFIT OF THE FILING DATES OF APPLICANT'S PRIORITY APPLICATIONS

Applicant claims priority under 35 U.S.C. 120 based upon U.S. Patent Application Serial No. 10/383,805 (the "'805 Application"), filed March 8, 2003, which is a continuation of U.S. Patent Application Serial No. 09/833,016 (the "'016 Application"), filed April 10, 2001, which is a continuation of U.S. Patent Application Serial No. 09/387,737 (the "'737 Application"), filed August 31, 1999, now U.S. Patent No. 6,213,225. The present Application is a continuation of the '805 Application, which is a continuation of the '016 Application, which is a continuation of the '737 Application. Therefore, the application of the terms of Claims 1-18 to the specification of the present Application in Section V above applies to the '805, '016 and '737 Applications as well.

The August 31, 1999 filing date of the '737 Application precedes the June 8, 2000 filing date of the '384 Patent. Therefore, Chen should be the senior party in the interference.

Applicant further claims priority under 35 U.S.C. 119(e) based on provisional application No. 60/098,466 filed August 31, 1998. Applicant is entitled to the benefit of the filing dates of his earlier filed applications for interference purposes if the count reads on at least one adequately disclosed embodiment in the earlier application.[2]

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[2] *See Weil v. Fritz*, 572 F.2d 856, 865-66 n.16, 196 USPQ 600, 608 n.16 (CCPA 1978).

CONCLUSION

Applicant has made an earnest attempt to place this case in condition for allowance. For the foregoing reasons, and for other reasons clearly apparent, Applicant respectfully requests full allowance of all pending claims. Furthermore, Applicant respectfully requests that the Examiner declare an Interference between the present Application and U.S. Patent No. 6,612,384.

If the Examiner feels that a telephone conference or an interview would advance prosecution of the present Application in any manner, the undersigned attorney for Applicant stands ready to conduct such a conference at the convenience of the Examiner.

Applicant respectfully requests that the Examiner handle this request to declare an interference with special dispatch. Furthermore, if the Examiner determines that any single claim of the present Application is not unpatentable, Applicant respectfully requests that an interference be declared in accordance with MPEP 2307.02, which states:

> When claims corresponding to claims of a patent are presented, the application is taken up at once and the examiner must determine whether the presented claims are unpatentable to the applicant on any ground(s), e.g., under 35 U.S.C. 102, 35 U.S.C. 103, 35 U.S.C. 112, 35 U.S.C. 135(b), double patenting, etc. If at least one of the presented claims is not rejectable on any such ground and is claiming the same invention as at least one claim of the patent, **the examiner should proceed to propose an interference**.

See MPEP 2307.02 – Rejection of Claims Corresponding to Patent Claims, first full paragraph (*emphasis added*).

The Commissioner is hereby authorized to charge any fees or credit any overpayments to Deposit Account No. 50-2148 of Baker Botts L.L.P.

Respectfully submitted,

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EXHIBIT A
Support for Claims 1-18

Reproduced below, are portions of the specification of the present Application that are examples of support in the present Application for each limitation of Claims 1-18 delineated below. This list is not intended to be exhaustive.

I. Support for Claim 1

A. ***A roller cone drill bit, comprising:***

1. *See Present Application, Figure 11.*

B. ***a bit body;***

1. *See Present Application, Figure 11.*

C. ***three roller cones attached to said bit body and able to rotate with respect to said bit body;***

1. *See Present Application, Figure 11.*

2. (1) The bit kinematics is described by bit rotation speed, Ω=RPM (revolutions per minute), and the rate of penetration, ROP. Both RPM and ROP may be considered as constant or as function with time.

(2) The cone kinematics is described by cone rotational speed. Each cone may have its own speed. The initial value is calculated from the bit geometric parameters or just estimated from experiment. In the calculation the cone speed may be changed based on the torque acting on the cone. *See Present Application, Page 12, lines 3-9.*

D. ***a plurality of cutting elements arranged on each of the cones so that cutting elements on adjacent cones intermesh between the adjacent cones, the cutting elements being arranged such that a projected area of said cutting elements in contact with a formation during drilling is substantially the same for each of the cones.***

1. The roller cone bit is energy balanced such that each of the cutting structures drill substantially equal volumes of formation. *See Present Application, Page 8, lines 20-21.*

2. Since the amount of formation removed by any tooth on a cutting structure is a function of the force imparted on the formation by the tooth, the volume of formation removed by a cutting structure is a direct function of the force applied to the cutting structure. By balancing the volume of formation removed by all cutting structures, force balancing is also achieved. *See Present Application, Page 16, lines 14-18.*

3. A roller cone drill bit comprising: a plurality of arms; rotatable cutting structures mounted on respective ones of said arms; and a plurality of teeth located on each of said cutting structures; wherein a substantially equal volume of formation is drilled by each said cutting structure. *See Present Application, Page 17, lines 5-8.*

4. (e) repeating steps (a) through (d) until substantially the same volume of formation is cut by each of said cutting structures of said bit. *See Present Application, Page 17, lines 23-24.*

5. The third application of the Row Cutting Ratio is to help to design a balanced cutting structure. This can be done by comparing the ratios of all the rows of a bit as shown in Fig. 3. Under the ideal condition, the Row Cutting Ratio of all rows should have the same value.

The Cone Cutting Ratio is defined as

$$\text{Cone Cutting Ratio\_n} = (\text{Sconecut} / \text{Sbottom}) * 100\% \qquad (3)$$

where Sconecut is the sum of cutting areas by all the teeth on a cone and Sbottom is the whole area of bottom and n represents the number of bit revolutions. *See '466 Provisional, Pages 5 and 7.*

II. Support for Claim 2

A. The drill bit according to Claim 1, wherein axial force exerted on the bit during drilling is substantially balanced between the cones.

1. The present application teaches that roller cone bit designs should have equal mechanical downforce on each of the cones. *See Present Application, Page 7, lines 7-9.*

2. Roller cone drilling wherein the bit optimization process equalizes the downforce (axial force) for the cones (as nearly as possible, subject to other design constraints). Bit performance is significantly enhanced by equalizing downforce. *See Present Application, Page 24, lines 2-4.*

III. Support for Claim 3

A. The drill bit according to Claim 1, wherein said cutting elements are disposed on each cone, such that work performed by each cone during drilling is substantially the same as the work performed each of the other cones.

1. With reference to **Figure 2**, the balance condition of a roller cone bit may be evaluated using the following criteria:

$$\text{Max}(\omega 1, \omega 2, \omega 3) - \text{Min}(\omega 1, \omega 2, \omega 3) <= \omega 0 \qquad (4)$$
$$\text{Max}(\eta 1, \eta 2, \eta 3) - \text{Min}(\eta 1, \eta 2, \eta 3) <= \eta 0 \qquad (5)$$
$$\text{Max}(\lambda 1, \lambda 2, \lambda 3) - \text{Max}(\lambda 1, \lambda 2, \lambda 3) <= \lambda 0 \qquad (6)$$

$$\xi = F_r \ / \ WOB * 100\ \% \ <= \ \xi 0 \qquad (7)$$

where ωi ($i = 1, 2, 3$) is defined by ωi = WOBi / WOB * 100 %, WOBi is the weight on bit taken by cone i. ηi is defined by ηi = Fzi / ΣFzi * 100 % with Fzi being the i-th cone axial force. And λi is defined by λi = Mzi / ΣMzi * 100 % with Mzi being the i-th cone moment in the direction perpendicular to i-th cone axis. Finally ξ is the bit imbalance force ratio with F_r being the bit imbalance force. A bit is perfectly balanced if:

$$\omega 1 = \omega 2 = \omega 3 = 33.333\ \% \ \text{or} \ \omega 0 = 0.0\ \%$$
$$\eta 1 = \eta 2 = \eta 3 = 33.333\ \% \ \text{or} \ \eta 0 = 0.0\ \%$$
$$\lambda 1 = \lambda 2 = \lambda 3 = 33.333\ \% \ \text{or} \ \lambda 0 = 0.0\ \%$$
$$\xi = 0.0\ \%$$

In most cases if $\omega 0$, $\eta 0$, $\lambda 0$, $\xi 0$ are controlled with some limitations, the bit is balanced. *See Present Application, Page 12, line 27 through Page 13, line 13.*

2. The forces on the teeth, cones, bearings, and bit are then calculated. Once the forces are known, they are compared, and if they are balanced, then the design is optimized. If the forces are not balanced, then the optimization must occur. Objectives, constraints, design variables and their bounds (maximum and minimum allowed values) are defined, and the variables are altered to conform to the new objectives. Once the new objectives are met, the new geometric parameters are used to re-design the bit, and the forces are again calculated and checked for balance. This process is repeated until the desired force balance is achieved. *See Present Application, Page 15, line 28 through Page 16, line 4.*

3. In the preferred embodiment of the present disclosure, a roller cone bit is provided for which the volume of formation removed by each tooth in each row, of each cutting structure (cone), is calculated. This calculation is based on input data of bit geometry, rock properties, and operational parameters. The geometric parameters of the roller cone bit are then modified such that the volume of formation removed by each cutting structure is equalized. Since the amount of formation removed by any tooth on a cutting structure is a function of the force imparted on the formation by the tooth, the volume of formation removed by a cutting structure is a direct function of the force applied to the cutting structure. By balancing the volume of formation removed by all cutting structures, force balancing is also achieved. *See Present Application, Page 16, lines 9-18.*

IV. Support for Claim 4

A. ***The drill bit according to Claim 1, wherein a depth of penetration for each cutting element into a formation during drilling is substantially the same for each of the cones.***

1. The force-cutting relationship for this single element may be described by:

$$F_{ze} = k_e * \sigma * S_e \qquad (1)$$

$$F_{xe} = \mu_x * F_{ze} \qquad (2)$$

$$F_{ye} = \mu_y * F_{ze} \qquad (3)$$

where F_{ze} is the normal force and F_{xe}, F_{ye} are side forces, respectively, σ is the compressive strength, S_e the cutting depth and k_e, μ_x and μ_y are coefficient associated with formation properties. These coefficients may be determined by lab test. A tooth or an insert can always be divided into several elements. Therefore, the total force on a tooth can be obtained by integrating equation (1) to (3). The single element force model used in the invention has significant advantage over the single tooth or single insert model used in most of the publications. The only way to obtain a force model is by lab test. There are many types of inserts used today for roller cone bit depending on the rock type drilled. If the single insert force model is used, a lot of tests have to be done and this is very difficult if not impossible. By using the element force model, only a few tests may be enough because any kind of insert or tooth can be always divided into elements. In other words, one element model may be applied to all kinds of inserts or teeth.

After having the single element force model, the next step is to determine the interaction between inserts and the formation drilled. This step involves the determination of the tooth kinematics (local) from the bit and cone kinematics (global) as described below.

(1) The bit kinematics is described by bit rotation speed, Ω=RPM (revolutions per minute), and the rate of penetration, ROP. Both RPM and ROP may be considered as constant or as function with time.

(2) The cone kinematics is described by cone rotational speed. Each cone may have its own speed. The initial value is calculated from the bit geometric parameters or just estimated from experiment. In the calculation the cone speed may be changed based on the torque acting on the cone.

(3) At the initial time, t0, the hole bottom is considered as a plane and is meshed into small grids. The tooth is also meshed into grids (single elements). At any time t, the position of a tooth in space is fully determined. If the tooth is in interaction with the hole bottom, the hole bottom is updated and the cutting depth for each cutting element is calculated and the forces acting on the elements are obtained.

(4) The element forces are integrated into tooth forces, the tooth forces are integrated into cone forces, the cone forces are transferred into bearing forces and the bearing forces are integrated into bit forces.

(5) After the bit is fully drilled into the rock, these forces are recorded at each time step. A period time usually at least 10 seconds is simulated. The average forces may be considered as static forces and are used for evaluation of the balance

condition of the cutting structure. *See Present Application, Page 11, line 12 through Page 12, line 21.*

V. Support for Claim 5

A. *The drill bit according to Claim 1, wherein a distribution of axial force on the bit is optimized.*

1. The present invention relates to down-hole drilling, and especially to the optimization of drill bit parameters. *See Present Application, Page 1, lines 11-12.*

2. The present application describes bit design procedures which provide optimization of downforce balancing as well as other parameters. *See Present Application, Page 7, line 32 through Page 8, line 2.*

3. Roller cone drilling wherein the bit optimization process equalizes the downforce (axial force) for the cones (as nearly as possible, subject to other design constraints). Bit performance is significantly enhanced by equalizing downforce. *See Present Application, Page 24, lines 2-4.*

VI. Support for Claim 6

A. *The drill bit according to Claim 1, wherein said cutting elements comprise superhard inserts.*

1. Insert bits have very hard inserts (e.g. specially selected grades of tungsten carbide) pressed into holes drilled into the cone surfaces. *See Present Application, Page 4, lines 9-10*

VII. Support for Claim 7

A. *The drill bit according to Claim 1, wherein said cutting elements comprise tungsten carbide inserts.*

1. Insert bits have very hard inserts (e.g. specially selected grades of tungsten carbide) pressed into holes drilled into the cone surfaces. *See Present Application, Page 4, lines 9-10.*

VIII. Support for Claim 8

A. *The drill bit according to Claim 1, wherein said cutting elements comprise milled steel teeth.*

1. Steel-tooth bits have steel teeth formed integral to the cone. *See Present Application, Page 4, line 7.*

IX. Support for Claim 9

A. ***The drill bit according to Claim 8, wherein said cutting elements further comprise hardface coating.***

1. Steel-tooth bits have steel teeth formed integral to the cone. (A hard facing is typically applied to the surface of the teeth to improve the wear resistance of the structure.) *See Present Application, Page 4, lines 7-9.*

X. Support for Claim 10

A. ***A roller cone drill bit, comprising:***

1. *See Present Application, Figure 11.*

B. ***a bit body;***

1. *See Present Application, Figure 11.*

C. ***three roller cones attached to said bit body and able to rotate with respect to said bit body;***

1. *See Present Application, Figure 11.*

2. See Paragraph I(C)(2). *See Present Application, Page 12, lines 3-9.*

D. ***a plurality of cutting elements arranged on each of the cones so that cutting elements on adjacent cones intermesh between the adjacent cones, the cutting elements being arranged such that a depth of penetration for the cutting elements into a formation during drilling is substantially the same for each of the cones.***

1. See Paragraph IV(A)(1). *See Present Application, Page 11, line 12 through Page 12, line 21.*

XI. Support for Claim 11

A. ***The drill bit according to Claim 10, wherein axial force exerted on the bit during drilling is substantially balanced between the cones.***

1. See Paragraph II(A)(1). *See Present Application, Page 7, lines 7-9.*

2. See Paragraph II(A)(2). *See Present Application, Page 24, lines 2-4.*

XII. Support for Claim 12

A. ***The drill bit according to Claim 10, wherein said cutting elements are disposed on each cone, such that work performed by each cone during drilling is substantially the same as the work performed by each of the other cones.***

1. See Paragraph III(A)(1). *See Present Application, Page 12, line 27 through Page 13, line 13.*

2. See Paragraph III(A)(2). *See Present Application, Page 15, line 28 through Page 16, line 4.*

3. See Paragraph III(A)(3). *See Present Application, Page 16, lines 9-18.*

XIII. Support for Claim 13

A. ***The drill bit according to Claim 10, wherein a projected area of said cutting elements in contact with a formation during drilling is substantially the same for each of the cones.***

1. See Paragraph I(D)(1). *See Present Application, Page 8, lines 20-21.*

2. See Paragraph I(D)(2). *See Present Application, Page 16, lines 14-18.*

3. See Paragraph I(D)(3). *See Present Application, Page 17, lines 5-8.*

4. See Paragraph I(D)(4). *See Present Application, Page 17, lines 23-24.*

5. See Paragraph I(D)(5). *See '466 Provisional, Pages 5 and 7.*

XIV. Support for Claim 14

A. ***The drill bit according to Claim 10, wherein a distribution of axial force on the bit is optimized.***

1. See Paragraph V(A)(1). *See Present Application, Page 1, lines 11-12.*

2. See Paragraph V(A)(2). *See Present Application, Page 7, line 32 through Page 8, line 2.*

3. See Paragraph V(A)(3). *See Present Application, Page 24, lines 2-4.*

XV. Support for Claim 15

A. ***The drill bit according to Claim 10, wherein said cutting elements comprise superhard inserts.***

1. See Paragraph VI(A)(1). *See Present Application, Page 4, lines 9-10.*

XVI. Support for Claim 16

A. ***The drill bit according to Claim 10, wherein said cutting elements comprise tungsten carbide inserts.***

1. See Paragraph VII(A)(1). *See Present Application, Page 4, lines 9-10.*

XVII. Support for Claim 17

A. ***The drill bit according to Claim 10, wherein said cutting elements comprise milled steel teeth.***

1. See Paragraph VIII(A)(1). *See Present Application, Page 4, line 7.*

XVIII. Support for Claim 18

A. ***The drill bit according to Claim 17, wherein said cutting elements further comprise hardface coating.***

1. See Paragraph IX(A)(1). *See Present Application, Page 4, lines 7-9.*